SCIENCE

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THE DRIFT OF PUBLIC discussion in England, not only among scientists, but also among athletes and others interested in physical training, seems to be against the acceptance of Professor Roy's defence of stays and corsets, at the recent meeting of the British Association. Some of the leading journals of London were instant in their approval of Professor Roy's theories; but where they have done so, immediate protests have come from their readers. *The Spectator*, for instance, in a recent number, after quoting Professor Roy's assertion that the desire for waist-belts is instructive, and has been displayed by all athletes, and persons of whom exertion is required, since the beginning of history, adds, "It will be observed that this argument, which is certainly true of all runners, Asiatic or European, applies to men equally with women, though men gird themselves only to meet special calls upon their strength." To this a recent graduate from Cambridge, where he was distinguished as a runner and long-distance bicycle-rider, protests that neither runners nor experts upon the wheel, at that university, ever used, or showed a desire to use, tight waist-belts. On the contrary, it was their custom to gird themselves as loosely as possible in order to allow free movement of the diaphragm. If rowers even wear waist-belts, they are so loose as to cause no interference with the freest movements of all the muscles of the body. It is probable that the habit of "girding up the loins" preparatory to physical exertion originated in Oriental countries, where in ancient times, and now as well, the peculiar form of the prevailing costume made it necessary in order to secure free movement of the limbs. A custom once established, needs no further explanation. It may survive long after there is any reason for it. The Hittites wore peaked-toed, turned-up shoes thousands of years after their ancestors had come from the mountains of the north, where the form of their snow-shoes suggested the peculiar fashion; and the daily life of every people is full of instances that might be cited. Nobody to day places restraint upon any of his organs if he desires to excel in feats of strength or speed. He may wear a waist-belt, but it is never so tight, as has already been remarked as to rowers, as to interfere with the free play of the muscles.

THE VERY ABLE PAPER on hydraulic degradation, by Director J. W. Powell, published elsewhere in this issue of *Science*, is the result — it would not be safe to say 'the final result' — of more than a dozen years of study and observation upon the subject. Former publications have simply indicated the direction in which this investigation was proceeding, and announced some of the conclusions reached. This is a comprehensive, brief, pointed, and easily understood exposition of the whole subject. *Science* congratulates itself upon being the first journal of its class, or of any class, to present this admirable paper to its readers. Major Powell is understood to invite comment, criticism, and discussion of the paper, and *Science* will gladly open its columns to communications on the subject.

THE APPROACHING RESIGNATION of Dr. John B. Hamilton, Surgeon-General of the Marine Hospital Service, to accept the editorship of the *Journal of the American Medical Association*, adds another to the frequent examples of the difficulty of retaining the bright men of science in the public service. During the last ten years Dr. Hamilton, by his energy and intimate knowledge of the service, has been able to carry out many reforms that could not otherwise have been effected. One very important one is the examination of pilots for color blindness, the establishment of new hospitals, the perfecting of the hospital regulations, which amounted to a thorough reorganization of the service and its general advancement, until, as *Colburn's United Service* (London) has declared, it is "the gem of the mercantile marine of the world." The means of preventing the spread of epidemics have been so simplified by Dr. Hamilton that most places subject to epidemic visitations have practically adopted the methods brought into use in this country by him. Dr. Hamilton's remarkable energy will soon make its effect felt in the pages of the *Journal*. Nothing is slow or dull that he has to do with, not even a medical journal. He will force others to quote from him, instead of making the *Journal*, as too many similar publications now are, a judicious selection of extracts from the exchanges. His Washington friends, of whom there are many, for he is personally very popular, will regret the loss of his society, but rejoice at his promotion.

THE LAWS OF HYDRAULIC DEGRADATION.[1]

THE lands of the earth are degraded by water, by ice, and by winds; hence in discussing geological degradation it becomes necessary to recognize hydraulic degradation, glacial degradation, and æolian degradation.

In hydraulic degradation three methods may be distinguished. 1. The surface of the land is disintegrated by various methods and washed away by rains and melted snows. The rains gather into streams, as brooks, creeks, and rivers, and transport the disintegrated rock from one region to another. This general surface degradation may be called 'erosion.' 2. During the process of this transportation the streams carve channels for themselves, and this channel-cutting may be called 'corrasion.' 3. By erosion, and also by corrasion, cliffs are produced, and these cliffs are broken down by gravity. This method of degradation may be called 'sapping.'

Thus there are three methods of hydraulic degradation, — erosion, corrasion, and sapping.

There are three processes involved in erosion: (*a*) the rocks are disintegrated; (*b*) the disintegrated material is transported in water; (*c*) in order to be transported in water the material must be loaded. In like manner, there are three processes in corrasion, — disintegration, loading, and transportation. In sapping there are but two processes, disintegration and falling.

In erosion and corrasion the material which is transported may be called the 'load.' The load is transported by two methods, a portion floats with the water, and another portion is driven along the bottom. The water in which the load floats is the 'vehicle' of transportation. Gravity is the force of transportation, and acts alike on the water and on the load. In the same sense that the water furnishes its own moving force, through its inherent gravity, so the floating load furnishes its own moving or transporting force through its inherent gravity. Vehicle and floating load alike are moved by gravity. The vehicle can move without the floating load, but the floating load cannot move without the vehicle; that is, the water is the agency of flotation for the load.

The floating load is in general of greater specific gravity than the water, and while floating, it falls to the bottom and comes to rest, and the progress down-stream of the floating load ends. The excursion which each particle will make from the time it is loaded to the time it is deposited depends upon four conditions: First, specific gravity. If the specific gravity is greater, the particle is deposited sooner; if the specific gravity is less, the particle is carried

[1] A paper read before the National Academy of Sciences at its meeting in New Haven, November, 1888.

farther. Second, degree of comminution. If the particle is larger, it will fall sooner; if the particle is smaller, it will be carried farther, for the smaller the particle the greater the supporting surface in proportion to its volume. Third, the velocity of the water. If the velocity is decreased, the excursion of the particle will be shortened; if the velocity is increased, the excursion of the particle will be lengthened. Fourth, the depth of the water. If the water is shallow, the floating particle will sooner reach the bottom; if the water is deeper, the particle will be carried farther before it strikes the bottom. In this subject, therefore, we have to consider the specific gravity of the load, the comminution of the load, the velocity of the water, and the depth of the water.

As the water runs down the channel, it may roll sediment along the bottom. This is the driven load. Such sediment is moved by the impact of the water from above. But in order to do this the materials on the bottom of the water must present up-stream surfaces on which impact may act; that is, the bottom of the channel must present heterogeneity of surface. This heterogeneity may be of such a nature that the passing water may by impact lift the particles from the bottom so that they will be transported in the vehicle by their own gravity. To the extent that materials are rolled along the bottom by impact, the energy of the water is utilized in transportation; but to the extent that transportation is accomplished by flotation, the gravity of the particles themselves is the entire force of transportation. Whatever is driven is transported by the energy of the water; whatever floats is transported by its own inherent gravity. This statement is made fully, because it is fundamental, and because the principles involved have been neglected and serious error has arisen therefrom.

The particles floating in a stream collide, and there arises therefrom inter-particle friction, but if in the collision between two particles one is retarded, the other must be accelerated. If the particles are broken or ground by the process, work is done, and the energy involved must be derived from the total energy of the moving water and load. Some energy, therefore, must be lost by it, but the disintegration arising therefrom promotes transportation, as the smaller particles make longer excursions. Heat is also developed and dissipated, but perhaps the quantities involved are unworthy of consideration.

There is a degree of comminution that so approximates molecular disintegration that some geologists and chemists believe that a *quasi* or *pseudo* combination between the water and the load results therefrom: if this be the case the character of the fluid is changed and the degree of fluidity is diminished. Here, again, it may be possible that the quantities involved are so small that they may be neglected.

The volume of water remaining the same, if the velocity of the water is increased, the depth of the water is diminished. Therefore the excursion of the particle will be lengthened by the increase of velocity, but shortened by the decrease of depth, and the one compensates the other. On the other hand, to increase the velocity of a stream enables it to drive larger particles; and this ability increases with the sixth power of the velocity.

The load increases the volume of the stream to the amount measured by its own volume, and the load increases the mass of the stream to the amount of its own mass; and as the load is of higher specific gravity than the water, the mass is increased at a higher rate than the volume. As load increases volume, it thereby increases velocity; and as load still further increases mass, it still further increases the effective energy of gravity.

In order that transportation by flotation may begin, the detritus must be loaded in the water, and when it sinks to the bottom it must be reloaded that flotation may be continued. In erosion, loading is primarily effected by the impact of raindrops. This loading is continued, and reloading is accomplished by the flow of the water over the surface through its impact against obstructions, and thus the wash of the surface is carried into the stream. But the load in the water sinks when, if the declivity is sufficient, it will be driven, but if the declivity is insufficient, conditions for its reloading must be produced. The driven load often becomes floating load when the water plunges over great declivities, but the chief method of reloading is by lateral corrasion: this arises in the case of deposits which are built up until they become portions of the banks of a stream and are subsequently attacked by the stream and carried away. Reloading is therefore chiefly accomplished by the process of lateral corrasion.

As the load is of greater specific gravity than the water, all load is over-load in the sense that the load must be deposited because the water is unable to permanently hold it in suspension. An extreme condition of load may be reached, which is sometimes exhibited in nature, in which the particles are so crowded that they cannot move freely in suspension; that is, they are in part held in suspension by the water and in part supported in position by one another, and still the particles may be so fine that they will slowly move down stream: in this case the water moves faster than the particles, and is strained through them at varying degrees. Thus partial hydraulic suspension may exist. At the one extremity the suspension may be so nearly perfect that the load is scarcely retarded thereby. At the other extremity the movement of the load may be wholly stopped and the water will be strained through it. Under such conditions streams may disappear from the surface and run wholly underground, and may re-appear when the accumulated sands have been passed. The accumulated sands may be of such an extent as to absorb all the water and hold it until it evaporates. Streams that thus empty into dry valleys and sand plains are abundant in arid regions.

The friction of pure water is so slight that where the formations are hard, corrasion cannot be accomplished thereby (all processes of solution are here neglected); but where the formation is incoherent, corrasion may progress through the impact of the water against the more or less disintegrated particles lying at the surface of the bottom and banks or on the 'wetted perimeter.' In this case the particles must present surfaces up stream, against which the flowing waters may act. The surface of the bottom and banks must be heterogeneous. Such disintegration must be accomplished by some instrument, and this is the load which passes along the channel in course of transportation; and it may be affirmed, that, other things being equal, the greater the load the greater the corrasion, and the less the load the less the corrasion. Again, the banks of the stream may be disintegrated by sapping, and loaded on the water by gravity, and the rate of lateral corrasion will be greatly increased thereby. But corrasion furnishes additional load, and it may be further affirmed that the greater the corrasion the greater the load, and the less the corrasion the less the load.

Rain is discharged from the surface of the land by flowing in the direction of greatest declivity, and as multiform heterogeneous and opposing declivities meet, the line of junction becomes the channel. A stream may thus have a line of maximum depth. If the channel is straight and homogeneous the line of maximum depth is the central line of the stream, which in many cases may be a broad zone; but it is deflected, now to one side and now to the other, by curvature and by a multiplicity of other conditions. The instrument of corrasion is the load, and chiefly the driven load which is drawn toward the line of maximum depth down the opposite declivities of the wetted perimeter by gravity, and thus corrasion is more or less concentrated along the line of maximum depth. Finally, the line of maximum depth is the line of greatest velocity, where impact is at a maximum. Hence it may be affirmed that in vertical corrasion the line of maximum depth is the line of maximum corrasion.

The geological formations into which channels are cut are greatly varied in constitution: they may be granite, basalt, limestone, sandstone, clay, alluvium, etc. Many degrees of hardness and coherence are presented in these varying materials. The beds themselves are not co-extensive with the land, but are always limited by the conditions of their production. Every such formation is a comparatively small bed of sand, gravel, clay, limestone, granite, etc., as the case may be, and the bed itself is variable in structure, as in thickness, hardness, and general constitution, through many degrees.

Geological formations are primarily horizontal, but subsequently they may be tilted by diastrophic agencies, so that some beds are horizontal, some are inclined at varying degrees, and others are vertical. Where in its course a stream passes from bed to bed, the conditions of corrasion are changed; the harder bed corrades with more difficulty, the softer bed with less. Where the beds are vertical, this change along the course is at a maximum; where the

beds are horizontal the stream slowly passes from one bed to another by reason of its declivity, and when the dip of a formation coincides with the declivity of a stream, the change which arises in passing from one formation to another is reduced to a minimum.

Heterogeneity of terrain has an important effect upon corrasion. Hard beds are corraded with difficulty, soft beds with ease. By this means the channel is broken into sections or reaches, now shorter, now longer, with the varying heterogeneity of the terrain, so that soft beds present reaches of lower declivity and hard beds reaches of higher declivity. The low-declivity reaches are expanded and the high-declivity reaches are contracted. Where the changes are more abrupt the declivity becomes more abrupt, so that the stream may be made to plunge in a part of its course and to flow gently in another part. The efficiency of corrasion is greater in the softer reaches, but the corrading power of the stream is increased with declivity, and thus the corrading power is concentrated on the harder reaches.

Under the conditions so briefly set forth, the smallest stream has a more or less heterogeneous terrain, and a great river like the Mississippi possesses a terrain of indescribable heterogeneity.

As maximum corrasion is along the line of miximum flow, progressive deepening of channel produces progressive narrowing of the channel; but this tendency is counteracted in various ways. The narrowing of the channel is checked by the instability of the banks. If the banks are greatly coherent, long-continued corrasion may result in the formation of deep cañons. As cohesion becomes less, the banks fall into the stream and the channel is widened; and when the terrain is composed of disintegrated materials the channel is widened until the banks have the normal slope. If the terrain is permeable to water, the material creeps into the channel and the slope is still further reduced. Quicksands that become saturated to the level of the stream, flow out, and excessive widening results therefrom. In the progressive lateral corrasion of an alluvial bank by the impact of the stream which is turned against it, wetting secures disintegration, and the banks progressively fall into the water. When the wetted perimeter — which is that portion of the channel surface covered by water — is below the channel perimeter, sapping results, and the load is still further increased. Given sufficient time, indurated banks assume the normal slope. Alluvial banks speedily assume this condition through the agencies which, considered together, may be called 'weathering;' and through the ever-recurring wash of rains the slope is ever diminished. In like manner, the most indurated banks — as of basalt, granite, or limestone — are reduced to low slopes. The stream corrading vertically through indurated rocks steadily increases its vertical banks below, while the weathering steadily decreases them above; so that the height of the precipitous portion of the banks is the residual of opposing agencies.

Corrasion is greatly modified by the declivity of the stream. This declivity may be so great that no portion of the load is deposited along its course. All the load is transported by flotation or driving. Under these circumstances, if the terrain of the channel is sufficiently coherent, the corrasion will be wholly vertical, and its rate will increase with the declivity, as the impact of the corrading particles will be increased thereby. This vertical corrasion will produce cañons with precipitous walls until at last cliffs thus formed will be broken down by sapping. But when along the course of a stream the declivity is diminished so that any portion of the load is deposited, such deposit serves to protect the bottom of the channel and to check vertical corrasion, but at the same time the channel is choked by the material thrown down, and the waters passing down the channel are turned to one side, and lateral corrasion is inaugurated thereby. In the same manner lateral corrasion is produced by the sapping of the cliffs, as the fallen cliffs choke the channel of corrasion, and the river is thus turned against its banks, which are high walls. Lateral corrasion therefore arises from local deposition and from no other cause.

If the declivity of the stream is diminished to such an extent as to prevent vertical corrasion, whatever corrasion exists must be lateral corrasion; and here again, the greater the load the greater the deposition, and the greater the resulting corrasion.

When a river flows over a plain with declivity so low that vertical corrasion is wholly checked, it is in a condition where lateral corrasion is at a maximum under the existing circumstances. This lateral corrasion is greater as the load is greater. Other things being equal, declivity determines whether corrasion shall be vertical or lateral, through the intervention of deposition.

In vertical corrasion the load is the instrument by which the channel is abraded, and in lateral corrasion the load is still the instrument with which the work is performed, but it is used in a twofold manner: (1) it is the agency by which the stream is turned against its banks, and (2) it is still an instrument of abrasion.

The volume of water is increased by every affluent: it is therefore progressively enlarged from source to mouth, and the conditions of corrasion and transportation are greatly modified thereby. At the junction of an affluent the volume of the stream is enlarged, and the rate of corrasion is increased, vertical or lateral, or both. If the declivity of the affluent is much greater than that of the principal stream, the affluent brings with it load too coarse to be further transported. In this manner the main river is choked, and is interrupted by a series of dams constructed by the affluents. This is especially remarkable in streams running in cañons. Where these conditions prevail, that form of the channel which is usually produced by heterogeneity of terrain — that is, by harder or softer formations — is sometimes obscured, or even obliterated, by affluent dams. The corrasion which results from increase of volume of water and sediment causes the channel below the affluent to be cut faster than the channel above. In this manner, *ceteris paribus*, a stream decreases in declivity from source to mouth, and a 'normal curvature of stream declivity' is produced thereby.

The volume of the stream is variable from time to time, as it depends upon the fall of rain and the melting of snow. This variable is great, as the flood-water volume may be many times that of the low-water volume. Increase of volume which arises in this manner manifests itself in part as an increase in cross-section and in part as an increase in velocity, and the rate both of transportation and corrasion is increased thereby. Corrasion and transportation are increased by another condition that arises simultaneously with the increase of volume. The rainfall which produces this increase also produces surface erosion. Surface erosion is intermittent, as it is caused only by the wash of rain and snow. When the storms come, the load is increased at a much higher rate than the volume of water in the stream. At low-water time the load is precipitated, and clear water flows in the stream, so that corrasion, transportation, and deposition are reduced, or even suspended. At flood time corrasion, transportation, and deposition are at a maximum. Whenever an affluent receives a local rain the volume of water is increased and the volume of load augmented at a still greater rate. When such an affluent discharges into a main stream which is slightly or not at all affected by the rainfall, the new load is at once thrown down, and the affluent dam is increased. Affluent dams are primarily formed by sudden decrease of declivity, and are greatly enlarged by local increase of volume. The effect of affluent dams is to stimulate lateral corrasion below. In a region of great declivity this is expressed in the widening of the channel; in a region of somewhat less declivity it is expressed in the enlargement of the flood-plain; and in a region of minimum declivity it is expressed in changing the position of the channel.

It has been shown that the channel of a stream is widened and narrowed by varied conditions of terrain. In soft formations it is expanded, in harder formations it is constricted. Another variable arises through the agency of affluent dams, as already explained. There is still another agency by which this heterogeneity is increased. The grand terrain of a river is subject to deformations, in such a manner that there may be upheaval in one part and subsidence in another. Subsidence alone may produce an expansion of channel at its locus, and upheaval may hold the waters back and produce expansion of the stream above the locus of displacement. By either or both of these methods the channels of great streams are largely modified, and even lakes are produced thereby. And streams are ponded by still other agencies that need not here be described. Stream-reaches expanded in this manner become areas of deposition where waters are largely discharged of load. In such cases streams are deprived of the instruments of corrasion, and corrasion is checked to the extent to which this is true. It has been seen that steep local declivities are formed by indurated geological

formations and by affluent dams. The ponding of streams by diastrophic and other agencies tends to convert the rapids of such declivities into cataracts. The plunging waters checked at the foot of the declivity are loaded by the impact and thrown into gyratory movements, as currents and whirlpools, and corrasion is thus greatly intensified at that point; and when the stream above is deprived of its instrument of corrasion by ponding, the corrasion at the foot of the rapids is much more intense that at the head, and thus it is converted into a cataract. Where geological conditions for sapping are most favorable, that is, where the strata are approximately horizontal and composed of harder and softer material, the cataract condition is still further promoted. It is thus that heterogeneity of width increases heterogeneity of declivity.

When a stream deposits load, the place of deposit is governed by a great variety of conditions. First, reaches of low declivity are reaches of deposition, and in ponded reaches deposition is excessive; Second, alluvial dams are sites of deposition; Third, when a stream corrades vertically and cliff banks are sapped, the material is at once deposited; Fourth, when cliffs are formed by lateral corrasion in flood-terrains the load is carried down stream, but maximum deposition occurs at the first quiet water below; Fifth, deposition sites are often adventitious. The most common agency of this character exists in the flood-wood carried by the stream. A floating tree may lodge below a reach of great lateral corrasion at the head of a region of equilibrium, where there is no lateral corrasion, and near to one bank. The tree so lodged may gather other driftwood, and inaugurate deposition, so that a bank will be rapidly constructed and built up into an integral part of the terrain. By this agency the stream may be turned against the opposite bank, and a great river-curve with a radius of one or more miles may be established, and thus square miles of the flood-plain may be cut away through the accident of a lodging tree.

It has already been seen how increase of load transforms vertical corrasion into lateral corrasion. There are two noteworthy illustrations of this fact that may well be further explained. When the stream debouches from a mountain course of high declivity to a plain or valley course of low declivity, a part of its load is suddenly deposited, the channel is thereby choked, and vertical corrasion is transformed into lateral corrasion. The stream is thrown against one and then against the other bank, and a flaring gorge is produced with its opening to the valley side and its apex in the mountains or hills. At the same time a broad, over-placed deposit is made, called an alluvial cone or alluvial fan. In this case it will be seen that as vertical corrasion is transformed into lateral corrasion the total amount of corrasion is increased thereby.

The trunks of great streams often run in low valleys where the declivity is so slight that all corrasion is lateral. Here the load is deposited, not uniformly throughout the channel, but wherever there are reaches of quiet water. The deposition from the initial load becomes less and less down stream from place of deposit to place of deposit. At every place of deposit a bank or bar is formed, which progressively becomes an impediment to the stream and around which the stream is turned in a curve. As it is diverted from its course it strikes with force against the opposite bank, and into this bank it corrades. If the banks are but slightly coherent the stream is loaded again with new material. This is greatly increased when the banks are cut in such a manner that the method of degradation by sapping is initiated, and this sapping is itself made more efficient if there are permeable strata into which the water penetrates so as to assist in sapping. The new load taken on in this manner serves further to choke the stream as it adds to the deposits below. In this manner the stream is turned against its banks at comparatively short intervals, and every curve is increased. This agency for the increase of tortuosity is counteracted by three other conditions that arise. First, two contiguous curves in the same river may increase until they coalesce, and a cut-off is established; Second, the increasing tortuosity is increasing length, and increasing length produces decreasing declivity, and the local corrasion is diminished thereby; Third, as the river swings from bluff to bluff across its flood-plain, by lateral corrasion, it works the materials over and over again, and grinds and regrinds the materials composing the banks; so that in the general average, the alluvium of the lower reach of the flood-plain is more finely comminuted than the alluvium of the upper reach. For this reason the load which is added from time to time in the downward course of the stream is more and more comminuted. Flotation is thus promoted; that is, the particles are held in suspension longer. The effect of this is that the particles make longer excursions and therefore choke the river less, and gradually they are robbed of their power of inducing corrasion. For this reason, when all the conditions are present, rivers running through low flood-plains become less and less tortuous as they approach their outlets — a condition well illustrated by the Mississippi River between Cairo and the Gulf. This law of tortuosity is interrupted wherever a lateral stream brings coarse material into the reach subject to the law.

In a stream where corrasion is wholly vertical the deposited load is driven along the bottom and reloaded from time to time, and the channel is thus kept clear of fixed deposits; but when a lesser degree of declivity is reached, so that the deposits choke the channel and cause lateral corrasion, the several deposits remain for a time to be attacked by the stream, which shifts its channel gradually or abruptly, as the case may be. When the declivity decreases to such an extent that corrasion is wholly lateral, the deposits become more permanent. A deposit once made is protected by subsequent deposits, and the process continues until bars and banks are built up into integral parts of the alluvial terrain. By this process the stream is turned against some other portion of the terrain, and loads itself again with new material. In the vicissitudes of channel-cutting recent bars and banks may sometimes be destroyed, but very rarely. To a large degree the deposits become permanent obstructions, continually increasing, until the river is wholly turned out of its course. By this process the tortuosity is produced and the channel is made to wander back and forth through the flood-terrain. In one sense the whole flood-plain valley, or rather the channel occupied by alluvial terrain, is the channel of the stream, and is occupied in part by the river and in part by deposits.

In this connection these two laws may be formulated: (*a*) When sediment is deposited it ultimately causes other sediment to be loaded; (*b*) The wider the flood-plain in proportion to the volume of the water, the greater will be the average length of time through which each deposit remains in place.

The forces of degradation are established by nature, and in general cannot be increased or diminished by man, and he can only control their operation to a limited degree. All of the forces in hydraulic degradation are of vast magnitude, and are far in excess of the powers actually utilized in the production of results, and when man deals with them he deals only with conditions. To make this clear to the mind, some illustrations may be useful. The following may serve for this purpose. The flood-plain valley of the Mississippi from Cairo to the jetties is about 550 miles in length and about 49 miles in breadth; that is, it has an area of about 27,000 square miles. If this flood-terrain be estimated to have an average depth of 50 feet, it would give a geological formation of about 250 cubic miles, which is wholly alluvial.

The forces of erosion are chiefly found in the precipitation of rain and snow from the heavens, and in the changes of the temperature from hour to hour and from season to season. Now let us suppose that all these forces could be utilized in the erosion of the described Mississippi flood-terrain, as they are sometimes utilized in bad-land hills, then the rate of erosion would be enormously accelerated. To get a clearer conception of these conditions, suppose that the whole flood-terrain were built into a system of hills having the normal slope of loose earth, and that between the hills there existed a ramification of streams, as rivers, creeks, brooks, and rills, and that the whole region was sufficiently elevated above the sea to give these streams a rapid flow, and that the rainfall of the region remains the same as at present, and that there be no protection from vegetation or other agencies, — then the present rainfall would erode away the described flood-terrain in less than five decades. Such conditions are sometimes found in nature, though rarely.

Now let there be built up in the mind a possible rate of corrasion when the conditions for the highest rate are at a maximum. The Mississippi River has been known to cut its banks at the rate of a mile a month, and yet the river was not utilized to the extent of its power; in fact, but a modicum of its corrading energy was brought

into play. Using still the flood-terrain as above described, let it be supposed that the river is turned against it in such a manner that the whole mechanical energy of the stream is directed against it, and suppose further that as fast as the banks are torn down by the impact of the water and the sapping of the banks the material is promptly carried away through the agency of great declivity, then the whole terrain would be carried away in less than ten years.

Next, let the rate of transportation under maximum conditions be illustrated, and still let the described flood-terrain be used for this purpose. Suppose that the terrain could be loaded upon the Mississippi in such a manner that the waters are constantly supplied to their utmost capacity. Now it has been observed in Utah, and again in Colorado in the case of certain bad-land streams, that under most favorable conditions water is capable of transporting its own volume of load. The Mississippi River annually discharges into the Gulf an average of one million cubic feet per second. If this volume of water were loaded to its utmost capacity, as described above, the flood-terrain of the Mississippi would be discharged into the Gulf in one year.

The rate of corrasion is subject to many interdependent variable conditions, Only the laws of the first order have been presented. There is still a great number of conditions of a second order to be considered; but they do not in any material way vitiate the laws already stated. The facts and principles that have been presented are those which the engineer must use in planning and constructing irrigation works. They are also of importance in dealing with the regimen of rivers for the purpose of improving navigation, and for the still more important purpose of protecting flood-plains from overflow. It is proposed here to call attention to some of the engineering methods which have been used to control rivers for the protection of flood-plains. Those selected for mention in this manner are as follows.

The banks of the stream may be protected from lateral corrasion by revetment, but such protection will be sufficient only to the extent to which it is applied; for thorough protection both banks must be revetted throughout the whole length of the flood-plain reach. And further, the revetment must be carried below the level of possible vertical corrasion or the revetment will be undermined. By this method the channel is protected from the choking which arises from the deposition of materials brought in from upper reaches, lateral tributaries, and local erosion. In a bank-protected channel along a flood-plain reach there is a constant tendency to distribute the obstructing deposits evenly along the bottom, as the lower declivities are sites of deposits and the higher declivities present conditions of increased vertical corrasion. In a river with uniform channel and uniform volume of water the deposition is uniformly diminished from head to foot, and such a stream builds up its channel until a degree of declivity is reached sufficient to carry away all the supply of load. If the declivity is more than sufficient to carry away the load supply, vertical corrasion is inaugurated and the channel is deepened. If the declivity is insufficient to carry away the supply of load, the deposit of sediment will build up the channel, and destructive floods will be increased thereby. Revetment, therefore, is efficient only on the condition that the declivity is exactly sufficient to carry away the load and to produce no further corrasion; for if vertical corrasion be increased, the revetment will be undermined and destroyed, and if vertical corrasion is insufficient, deposits will be made and floods will result. The practical problem, therefore, is to decide whether the declivity is or is not sufficient to preserve the channel. This problem is always solved by nature, and its solution is made perfectly plain. If the declivity of the flood-plain reach is sufficient to preserve the channel, the channel will be preserved, and there will be no lateral corrasion. Every flood-terrain is such because the channel of the stream has an insufficient declivity for its own protection. The very fact that corrasion is wholly lateral is in itself an absolute demonstration that the declivity of the stream is insufficient for the protection of the channel. This arises from the fact that the load once deposited remains, as the channel does not present conditions for its reloading: revetment, therefore, is necessarily futile, except for local and temporary purposes.

If portions of the banks of a channel are revetted, the only result arising therefrom is to change the locus of lateral corrasion; for, the total deposits remaining the same, the total lateral corrasion will remain the same. If the whole channel is revetted, the whole channel will be built up thereby, and ever a greater volume of water will be distributed over the flood-plain, until the channel is entirely filled at its head, or built up to such a declivity that vertical corrasion will be sufficient to preserve the channel.

There are four other methods that have been presented by engineers and geologists still worthy of consideration, as they are more or less efficient, either separately or conjointly. These are as follows.

1. The channel of the stream may have its banks and bars removed, and it may be deepened by river ploughs. To be efficient, the clearing of the channel of its deposited obstructions must be complete. The effect of clearing a lower reach is not extended to an upper reach, but the effect of clearing an upper reach is to increase the obstructions of the lower. For this reason the channel must be cleared its entire length throughout the region to be protected from floods at one effort.

2. The channel of the river may be shortened. By this method the declivity of the stream will be increased, the velocity of the current increased, and the waters more rapidly discharged. At the same time the channel of the stream will be deepened progressively from the foot to the head of the reach, where the stream runs through alluvial formations; but wherever the stream has its bed in indurated rocks the progress of stream deepening will be retarded.

The shortening of the channel may be accomplished by two methods.

a. By establishing a nearer outlet.

b. By utilizing and promoting cut-off reaches.

3. The headwaters and tributaries may be impounded in reservoirs at flood time and held until low water, and the volume through the year may thus be more or less equalized.

4. The headwaters and tributaries of a river may have their waters drawn off into settling basins, and thus they may be caused to discharge the sediment they carry, which is the material which forms the deposits and chokes the channel, and also the instrument of lateral corrasion.

It is manifest that the storage of water and the discharge of sediment may be accomplished by the same agency.

It is the purpose here merely to mention the principal efficient methods of controlling rivers in their flood-plain reaches. Every river presents problems more or less peculiar to itself, and the application to special cases of the laws which have been set forth is one of great interest and of profound importance.

J. W. POWELL.

COMMERCIAL GEOGRAPHY.

The Care of our Forests.

IN the annual report of the Department of Agriculture, B. E. Fernow, chief of the forestry division, dwells most emphatically upon the necessity of adopting a sound policy regarding our forests. His interesting report is accompanied by a map showing the distribution of forests in the Rocky Mountains, where they serve the important purpose of regulating the flow of springs and streams. Mr. Fernow's weighty arguments and urgent demands for better care of our forests ought to attract the most speedy attention of our legislators. He says, —

"It has become evident, in spite of the enormous supplies which seemed to be available, that our natural forests are being rapidly reduced, both by an increased demand and by wasteful practices; and it is now safe to say that the annual consumption of wood and wood-products is at least double the amount reproduced on our present forest area. The forest, under proper management, is capable of furnishing continuous crops, and therefore, as a source of constant supply, demands national legislation.

"It has become evident, that with the unrestrained scourge of fire and the destruction by herding, and other malpractices now prevalent, and in the absence of all rational forest management, not only is the remaining forest deteriorated in material value, but large tracts of land are converted into absolute deserts or useless bar-

rens. A sound land-policy, therefore, demands that the nation should give earnest attention to forest management.

"It has become evident that we are not to escape the consequences of disturbing the even distribution of water-flow by forest devastation, and denudation of mountains and hills, which have been experienced in other parts of the world, and which have reduced fertile lands to barrenness, prosperous communities to poverty. Regard, therefore, for the future welfare of the several communities which in their aggregate represent the nation, calls for a rational forest policy, a proper utilization, a proper distribution, and a proper management of the natural forest.

"Lastly, if the nation as such is interested in the proper development of the rich agricultural lands of the plains and prairies, it must be interested also — in that part of its domain, at least — in forest-planting as a means of ameliorating climatic conditions and making the region more habitable."

Mr. Fernow then proceeds to consider the most immediate needs and the most immediate duty of the general government in regard to the forestry question. "The general government still holds, as an individual, national property, a forest area the extent of which is unknown, but may be estimated between fifty and seventy million acres. The bulk of these lands is to be found on the rugged mountain sides and crests of the Western ranges, notably the Rocky Mountain, Cascade, Sierra Nevada, and Pacific coast ranges, mostly land not fit for agricultural use. The agricultural valleys at the foot of these ranges are not only destitute of timber, but they are dependent for their agricultural productions upon irrigation, the water for which is derived from the mountain-streams and more rarely from artesian wells, both of which sources are fed by the rains and snows which fall upon the forest-covered mountain-sides, and gradually find their way to the plain below. It has been proved not only by experience, but by actual experiment on a large scale, that forest cover regulates and beneficially influences the rapidity with which these precipitations are carried to the plain for utilization on agricultural lands."

In order to preserve these woods, a bill has been formulated, which has been submitted to Congress through the agency of the American Forestry Congress. Its essential features are the withdrawal from sale, or other disposal, of all woodlands still in the hands of the government, and the classification of the same into three classes; the regulation of the sale of timbered land which is fit for agriculture; and the management of the forests occupying land unfit for agriculture. To insure a proper administration of such a law, to prevent waste and loss by fires, a new bureau in the Department of the Interior is proposed, with a forest commissioner and four assistant commissioners acting as a forestry board.

"None but such a thorough organization can be expected to guard the national property, of which, under the present neglect, the nation is annually robbed to the extent of from five to ten million dollars, not counting the damage done by fires and fraudulent operations of speculators. But, as has been stated repeatedly, the forest-cover in the localities in which the bulk of the public timber-lands is situated, notably on the Rocky Mountains and the Pacific slopes, subserve a function which makes its material value of only secondary importance. It has become already evident that the denudation of mountain-sides in the region under consideration has impaired the regularity of water-flow, upon which irrigation in the arid valleys below depends.

"The interest of the nation, therefore, in properly administering this property, reaches beyond that of any material advantage; and certainly in these mountain forests, in this legislation for their proper administration, lies the immediate national interest in forestry."

ELECTRICAL SCIENCE.

The Heroult Aluminium Process.

THE Swiss Metallurgical Company, established close to the Rhine Fall at Neuhausen, has adopted the process of M. Heroult for the production of alloys of aluminium. The process resembles in some ways that of the Cowles brothers, which is so successfully employed at Lockport in the United States, and which has been recently introduced in England and the continent. In both the Cowles and Heroult processes an electric current is employed. In the former it is used simply to produce a very high temperature in a limited zone, the reduction of the ore being due to the temperature alone and not to any effect of electrolysis, so that an alternating could be used as well as a continuous current. In the Heroult process, according to the views of the inventor, the reduction of the ore is partly electrolytic and partly due to the heat of the arc. The furnace has a carbon pole at the top, and the current passes in by it through the melted aluminium oxide to the reduced metal at the bottom; the ore is decomposed, the oxygen passing upward and attacking the carbon, while the molecules of the metal travel downward and are merged in the metal bath.

The furnace used in the process is a large carbon block hollowed out in the proper shape and enclosed by a frame of iron. In the smaller furnaces a single block of carbon is used and the iron is cast around it; for larger sizes slabs of carbon are used, and are held together by wrought-iron bands. There is an opening in the bottom of the furnace for drawing off the reduced metal. The current enters the crucible through a carbon electrode which enters the top, and which consists of a bundle of carbon slabs, ten feet long, seventeen inches wide, and nine and a half inches deep. The distance of this electrode from the surface of the molten metal is regulated by an attendant. This distance is very small, preferably not over a quarter of an inch. One of the electrodes is consumed in producing about half a ton of aluminium. The crucible is covered by carbon slabs insulated from the body of the crucible; in the top, holes are provided for the introduction of ore and scrap metal. The ore generally used is alumina, free from silicon and other impurities, and the scrap metal is either iron or copper, according to the alloy which is desired. The process of smelting is a continuous one, the ore being introduced and the crucible tapped at regular intervals. The production of aluminium per horse-power hour varies somewhat with the percentage of the metal contained in the alloy, the average being thirty grams of aluminium and the maximum being forty grams. That is, to produce one pound of aluminium requires fifteen horse-power hours on the average, and eleven horse-power hours under favorable conditions. The present capacity of the crucible is four hundredweight of aluminium in twenty-four hours.

At the works at Neuhausen the current is produced by two dynamos driven by a turbine of three hundred horse-power. These dynamos are of the multipolar type, designed by Mr. C. E. L. Brown, and built at the Oerlikon Engineering Works. They are designed to give six thousand ampères each, at an electromotive force of twenty volts, and they can be worked up to thirty-five volts. The speed of the turbine is controlled by an automatic regulator acting upon a throttle in the inlet-pipe of the turbine. While the working current is normally twelve thousand ampères, it sometimes increases to twenty thousand ampères, because of a short-circuit in the furnace, caused usually by one of the slabs of which the carbon electrode is made burning more slowly than the others and touching the surface of the molten metal. This increase of current does not injuriously affect the dynamos. There is no sparking at the brushes of the dynamos. The process promises to be a successful one; from the figures given it compares favorably with the Cowles process in the amount of aluminium reduced per horse-power.

AN IMMENSE ELECTRIC LIGHTING STATION. — In the London *Electrical Review* is a description of the station of the London Electric Supply Corporation. At the Stowage wharf, Deptford, this corporation is laying down plant sufficient for the supply of 250,000 incandescent lamps, and there is space for three other sets similar to the first, giving a final capacity of one million lamps. The grounds of the corporation have a river frontage, with a wharf for landing fuel and heavy machinery. A fifty-ton derrick has already been erected. The buildings occupy a space of 210 by 195 feet, and the height will be 100 feet.

The boiler house is 195 by 70 feet, and is constructed to hold boilers of 65,000 horse-power, and of these, 13,000 horse-power are being erected. The boilers will occupy the two lower floors, with stowage room above for the fuel. The two engine houses are of nearly the same dimensions as the boiler house, and are very massive in construction. In the first of these houses a pair of 3,000

horse-power engines will soon be erected, and will drive two Ferranti dynamos, each capable of supplying current for 25,000 lamps. These are the largest electric generators in the world, and we can get some idea of the increasing size of dynamos when we remember that four years ago the largest practical machines were Edison's 'Jumbo' dynamos of 1,200 lights capacity. In the second engine room will be placed two sets of engines and dynamos. These are combined in such a manner that the armatures of the dynamos are driven directly by the engines and act as their fly-wheels. The speed is but sixty revolutions per minute. There will be four dynamos, and they will finally have each a pair of 10,000 horse-power engines. At present they are to have but 5,000 horse-power each. All future extensions of plant will be in these units. The dynamos will weigh 500 tons, and the armatures will be 45 feet in diameter.

The distribution will be on the alternating current system. The current leaves the station at the enormous potential of 10,000 volts, and is taken to a number of distributing stations where a first conversion takes place, lowering the potential to one or two thousand volts; then it is taken to the points of consumption, where a second conversion takes place and the voltage is lowered to that necessary for the lamps.

The main cable, $2\frac{5}{8}$ inches in external diameter, is formed of two concentric tubes of copper. An insulating compound separates the two tubes, the central portion of the cable being hollow: the sectional area of each tube is .5 of a square inch.

The first two dynamos of 1.500 horse-power each are nearly completed, and will soon be erected; two of the 10,000 horse-power dynamos will probably be finished in about five months. The space now covered with buildings will accommodate 40,000 horse-power, and the rest of the space available can accommodate 80,000 horse-power more, a total capacity of 120,000 horse-power.

This station, in capacity and the enormous potential used (the maximum electromotive force is about 15,000 volts), far surpasses any thing that has been attempted in this country or anywhere else. It is hardly to be hoped that the scheme will succeed without great trouble and discouragement at first, since many of the conditions are new; but whether it finally fails or succeeds, the experience it will give will be of great benefit to electricians.

ELECTRO-DEPOSITED COPPER. — Messrs. Elmore, in England, have introduced a process for the production of pure copper tubes, wire, etc., by which very satisfactory results have been obtained. The general method of producing a tube is to immerse a revolving mandrel, nearly surrounded by bars of Chili copper, in a bath of copper sulphate, and send a current of electricity between the bars and the mandrel. The ordinary result would be the deposition of crystalline copper, with little adhesiveness and strength. The essential feature of the process is a burnisher pressing lightly on the surface of the copper, travelling on a leading screw from one end of the mandrel to the other, its motion being automatically reversed when it reaches either end. The result is a tube of great density and strength, and without lines of weakness as in ordinary tubes.

When it is desired to make wires, tubes of any desired length and thickness are cut spirally into square wires, and these are afterwards drawn to the required size and shape. The conductivity is greater than that usually obtained in commercial wire, and is even greater than that of the samples determined by Dr. Matthiessen, who used the greatest care in obtaining his specimens of copper. Tests made on annealed and hard-drawn wires give respectively 102.4 and 104.44 per cent of the conductivity obtained by Dr. Matthiessen for pure copper.

BOOK-REVIEWS.

Researches on Diamagnetism and Magne-Crystallic Action. By JOHN TYNDALL. New York, Appleton. 12°. $1.50.

WHEN Tyndall undertook the first of the researches contained in this volume, the attention of physicists had been drawn to the remarkable phenomena exhibited by certain substances, metals, and other matter, and by crystals when placed in a magnetic field. It was found that various substances, notably bismuth, were repelled by magnetic poles instead of being attracted; and it was stated that crystals in a magnetic field tended to take up a definite position, but were neither attracted nor repelled. With respect to the first of these phenomena, the questions which arose were, 'What is the nature of this diamagnetic force?' 'Does it correspond to magnetic force but with an opposite direction?' Faraday first thought that the phenomena might be explained by assuming in diamagnetic bodies a polarity the reverse of that in magnetic bodies; but he soon abandoned this view, and held that the apparent diamagnetism of bodies was caused by their being less magnetic than the medium in which they were placed. A diamagnetic body was with him a body less magnetic than air.

Tyndall, in these memoirs on the subject, has with great ingenuity, and with apparatus at once powerful and delicate, compared the deportment of diamagnetic with magnetic bodies; and "the antithesis between them, when acted on by all possible combinations of electro-magnets and electric currents, was proved to be absolute and complete. . . . No reasonable doubt, therefore, could rest upon the mind that the diamagnetic force possessed precisely the same claim to the title of polar force as the magnetic."

This work of Tyndall's was done over thirty years ago. The attention of physical scientists was called to other electrical and magnetic phenomena, and no really important experiments on magnetization were tried until 1872, when Stolltow and Rowland published their well-known researches. But in the last few years interest has again centred in magnetic phenomena, and it is well that attention should be called to earlier experiments.

The present edition of 'Diamagnetism and Magne-Crystallic Action' differs from the original in the omission of some parts that are of little interest now. As a clear description of difficult, ingenious, and successful experiment, it should form part of the library of every physicist.

Tales of the Birds. By W. WARDE FOWLER. London and New York, Macmillan. 12°. $2.50.

THIS book is hard to classify, being a series of eight fancy sketches, consisting of imaginary bird-talk, with little obvious point, and containing little that can be seriously called ornithological. It is designed, perhaps, to illustrate certain incidents of bird-life, as the hard struggle for existence of English field-fares in winter, the dangers and mishaps befalling birds during migration, etc. The birds are supposed to tell their own tales. The slight web of fact is heavily padded with light fancies, designed doubtless to interest especially juvenile readers, who may find the book somewhat attractive. The book is English in its scenes and subjects. The writer is obviously familiar with bird-ways, and might write well in a more serious vein. The eight full-page illustrations are quite in keeping with the general character of the text. The title of the book is about all that would suggest its classification as a natural-history publication.

A Manual of the Vertebrate Animals of the Northern United States. By DAVID STARR JORDAN. 5th ed. Chicago, A. C. McClurg & Co. 12°. $2.50.

THE present edition of President Jordan's well-known 'Manual' is much enlarged in scope, and so completely rewritten and rearranged as to be in many respects not only greatly improved, but practically a new work. The geograpical area is extended westward from the Mississippi River to the Missouri River, and the marine forms (excluding the deep-sea species and those of merely accidental occurrence) are for the first time included, the coast region thus covered extending from Nova Scotia to Cape Hatteras. The artificial keys of the former editions have in great part given place to analytical keys based on differential characters. While this change may render slightly more difficult the quick recognition of species by the inexperienced student, it has the advantage of making known more clearly the actual basis of classification. The order of succession of groups is also reversed, the lowest or more generalized standing first; the 'Manual' beginning with the fishes, and ending with the mammals. By the omission of synonymes and references, except in special cases, the use of smaller type and a larger type-bed, the amount of matter has been much increased, while the number of pages is lessened and the typographical appearance of the book greatly improved. In classification and nomenclature the work is fully abreast of the latest discoveries and conclusions in respect to

each of the classes treated. With its enlarged scope, more extended diagnoses, and improved keys, the 'Manual' must now prove even a more efficient and satisfactory aid to both student and teacher than heretofore, and prove fully worthy of the extended patronage it is sure to have.

Hygiene of the Nursery. By LOUIS STARR. Philadelphia, Blakiston. 8°. $1.50.

OF the many books which have been published on this subject, the one now before us is by far the best. The plan of the author has been to point out a series of hygienic rules, which, if applied to the nursery, can hardly fail to maintain good health, give vigor to the frame, and so lessen susceptibility to disease. He has done his part well, and if he shall receive the co-operation of the mothers and of the physicians, his self-appointed task cannot but result in much good everywhere, and, in many families, in a complete revolution. While Dr. Starr has evidently had especially in mind, in the preparation of this manual, the mother and the nurse, his book is one which every physician should possess. In the opening chapter the author describes the "features of health," by which term he refers to the evidences which healthy children manifest of their well-being. Of these, every mother should have a full knowledge; so that, by appreciating variations, she may anticipate the complete development of disease, and early summon skilled aid at the time when it is of most service. In speaking of the nursery, Dr. Starr says that in every well-regulated house in which there are children there should be two nurseries, — one for occupation by day, the other by night, — and that the best and sunniest rooms should be selected. The size, lighting, furnishing, heating, and ventilating of the nursery are described in detail. The qualifications of the nurse-maid are mentioned, and the author then passes on to the kind of clothing which children should wear at different periods of life. Separate chapters are devoted to exercise and amusements, sleep, bathing, food, dietary, and emergencies. We are glad to see that Dr. Starr condemns the rubber and glass tubing in connection with the nursing-bottle. He speaks of these appurtenances as "not only an abomination, but a fruitful source of sickness and death." His language is none too strong. Physicians and others connected with dispensaries and summer homes for sick children regard these tubes as intimately connected with the production and continuance of bowel-troubles, and begin the treatment of such cases by discarding the tube, and substituting a simple rubber nipple. The reason for this is, that these tubes cannot be cleansed, and the milk which passes through them becomes decomposed, and contaminates all the milk which subsequently is drawn from the bottle by the child. In the chapter on emergencies, the immediate treatment of bruises, sprains, fractures, cuts, burns, scalds, stings of insects, foreign bodies in the ear, eye, nose, and throat, ear-ache, nose-bleed, colic, and convulsions, is described, as is also the method of disinfection after contagious diseases. Taken as a whole, Dr. Starr has given the public an exceedingly practical, and therefore valuable book. His language is simple, and devoid of technicalities, and there is no portion of it which cannot be readily understood by every intelligent person.

Names and Portraits of Birds which interest Gunners, with Descriptions in Language understanded of the People. By GURDON TRUMBULL. New York, Harper. 12°.

IN some respects Mr. Trumbull's book covers new ground, its two chief objects being to provide gunners with plain, non-technical descriptions and simple black-and-white figures (woodcuts) of the birds in which they are interested, and an elucidation of the vernacular names applied to our game-birds. This latter is perhaps the true *raison d'être* of the work. The labor and time the author must have given to this phase of the subject are evidently very great, and the results are of much interest, as well as of practical utility, not only to gunners and sportsmen, for whom the work is primarily intended, but for ornithologists and philologists as well. The quaint title very fully expresses the scope and purpose of the work. The number of species treated is sixty-one, of which more than half are ducks and geese, five are members of the rail family (*Rallilæ*), nine are shore-birds, plovers and sandpipers, and five are grouse. Each species, including its various phases of plumage, is described fully in "language understanded of the people." He says, possibly with some truth, "Few, even among our most intelligent college-bred sportsmen, can form a clear idea of a bird's appearance from the 'shop-talk' of scientists, even though provided with a glossary."

About ninety very beautiful woodcuts, drawn by the well-known bird-artist, Edwin Sheppard of Philadelphia, effectually supplement the text; figures of both male and female being given, when, as among the ducks, the sexes greatly differ in plumage. The technical names are those of the American Ornithologists' Union 'Check-List of North American Birds,' and the habitats are usually given from the same source.

The greater part of the text is devoted to the common vernacular names of the various species treated, little being said about habits. While synonymy is such a bane and burden in scientific literature, Mr. Trumbull's book shows that in the case of vernacular names, which our author so delightingly collates, the number and complexity of aliases are far greater, and the unravelling of the tangled skein much more difficult; "so many names being used for more than one species, and so many having been given to one and the same bird." The pintail duck (*Dafila acuta*), for example, rejoices in thirty-one distinct English aliases, not counting numerous simply orthographic variations; while the surf scoter (*Oidemia perspicillata*) and the old squaw (*Clangula hyemalis*) have respectively thirty-three and thirty-four distinct vernacular designations. Half that number is about the rule, while the ruddy duck (*Erismatura rubida*) heads the list with *sixty-seven!* Many of these names are extremely local, and the author does well to give explicitly the localities where they are in use. "The principal reasons for this multiplication of names are obvious: viz., differences in size, shape, and color between males and females; periodical changes in plumage; mistaking one variety for another; and, more particularly, differences of opinion as to the names most appriate." In some instances a whole set of names is based on each striking feature of the bird, as of the bill or tail, or on coloration, or on peculiarities of habits. "Many of these names probably appear now for the first time in print, yet few are of recent origin; and, though some may be a little time-worn, they are time-honored, and as familiar in certain localities as 'cow,' 'dog,' and 'cat.' . . Names which appear to us absurdly grotesque and outlandish are mediums of communication between men as wise as ourselves, though educated in a different school; and the homely nomenclature of those who shoot, not alone for sport, but for their daily bread, should command respect." As already said, Mr. Trumbull's book is especially interesting from the standpoint of philology, as showing how words originate and language grows.

A very full index completes this admirable work; but a table of contents, giving lists of the species treated and of the illustrations, would also have been of great convenience.

Essays on God and Man, or a Philosophical Inquiry into the Principles of Religion. By HENRY TRURO BRAY. St. Louis, Nixon-Jones Printing Co. 12°. $2.

THIS work is written by an Episcopal clergyman of Missouri, and deals with the bearings of evolutionism and other scientific theories of the present day on the accepted doctrines of religion. The author is clearly imbued with both the religious and the scientific spirit, is thoroughly in earnest, and writes for the most part in perfect good temper. Sometimes his repugnance to certain superstitions that have gathered around Christianity leads him to use expressions that are a little rough, and those parts of the book might better, perhaps, have been omitted, as the doctrines thus attacked have already lost their hold upon thinking minds; but on the whole the tone of the work is excellent. The style, also, is simple and clear, and never leaves us in doubt as to the author's meaning. Mr. Bray's religion is based upon scientific doctrines on the one hand, and, on the other, upon all that is best in the religious teachings of the whole world. He maintains that the science of the present day is religious, and gives some quotations from scientific writers in proof of this assertion. He holds strongly to the evolution philosophy, though believing that we can know more of the divine attributes than most evolutionists admit; and he defines God as "universally extended Conscious Force." He re-

jects the doctrine of inspiration as heretofore taught, and maintains that all scholarly theologians do the same. A religion in harmony with science may, he thinks, be founded on the following doctrines: "1°. There is an Infinite Intelligence whom we call God; 2°. Man is by nature a religious being; 3°. Every religion has in it a nucleus of truth; 4°. No religion is exclusively true or founded upon an exclusively divine revelation." Christianity, however, is regarded as the best of all religions, and as the "highest outcome of human nature." Mr. Bray quotes many passages from non-Christian religious writers, including the Greek philosophers, the authors of the Vedas, the Chinese moralists, and many others, in support of his positions; and these quotations form an interesting portion of the book. On the subject of immortality the author speaks with hesitation, presenting the arguments on both sides, and drawing the conclusion that there is ground for hope but not for dogmatizing. Our readers will see that there is nothing essentially new in these views; but as coming from a clergyman, and addressed to a congregation of the people, — for they were originally presented in public lectures, — they have considerable interest, and Mr. Bray's book will well repay perusal.

A Text-Book of Euclid's Elements. By H. S. HALL and F. H. STEVENS. London and New York, Macmillan. 12°. $1.10.

THIS volume contains the first six books of Euclid's elements, together with appendices giving the most important elementary developments of Euclidean geometry, The text has been carefully revised, and special attention given to those points which experience has shown to present difficulties to beginners. The authors have been guided in part by the suggestions contained in the text-book of the Association for the Improvement of Geometrical Teaching. The propositions are throughout treated very fully, and the authors have avoided condensing two or more steps into one. In this they were guided by the weighty consideration that only a small proportion of those who study elementary geometry, and study it with profit, are destined to become mathematicians. To a large majority of students, Euclid is intended to serve not so much as a lesson in mathematical reasoning, as the first, and sometimes the only, model of formal and rigid argument presented in an elementary education.

NOTES AND NEWS.

THE Christmas number of *Scribner's Magazine*, which completes its second year, will contain a variety of articles in prose and verse, especially suited in sentiment and illustration for the holiday season. There will be twenty full-page pictures, and many others from drawings by such artists as Elihu Vedder, J. Alden Weir, W. Hamilton Gibson, Bruce Crane, and Robert Blum. The art of making stained-glass windows, which has had its renaissance in this country within the last twelve years, will be the subject of a paper by Will H. Low; the third and concluding instalment of Lester Wallack's reminiscences will appear; George Hitchcock (the artist, whose picture, 'The Tulip Garden,' in the Paris salon of 1887, made his reputation) has written and illustrated for the number a short paper on 'Sandro Botticelli,' as 'the man who, above all others, gave an impulse in the right direction to the new art of the Christian world,' and Elihu Vedder has illustrated a strikingly original anonymous poem which will, it is believed, excite considerable curiosity as to its authorship. —— *Treasure Trove* for November opens with an illustrated account of the Lick Observatory, followed by articles on the Wilkes-Barre accident; the Canadian fish question; the disagreement of the doctors; the Chicago riots; and the wheat corner, under the caption 'Is that the Law?' by Wolstan Dixey; 'Yellow Fever,' by W. H. H.; 'A Famous Astronomer,' with portrait of the late Richard A. Proctor; 'American Politics,' by Oscar R. Hart; 'Getting Ready for Christmas,' with illustrations, by Lucy Clarke; 'Russian-America' (second paper), illustrated. Besides this are illustrated papers on 'Mary Stuart,' by J. R. D. L.; 'Crystals,' by Margaret E. Houston; 'Children's Lunches;' 'The Metal of the Future;' 'What Congress Costs,' and others. —— A new edition of Browning's Educational Theories, with a complete analysis, a new index, and an appendix on the 'American Common School,' will be issued at once by E. L. Kellogg & Co., of New York and Chicago. Also Dr. Nicholas Murray Butler's 'The Argument for Manual Training,' and a new edition of Perez's 'First Three Years of Childhood.' G. Stanley Hall says of this last book, "I esteem the work a very valuable one for primary and kindergarten teachers and all interested in the psychology of childhood." ——The first step in avoiding mistakes is to find out how we fall into them. Valuable aid in this direction will be furnished in Prof. Joseph Jastrow's paper on 'The Psychology of Deception,' which will open the December *Popular Science Monthly*. As illustrations of his subject the author cites the tricks practiced by conjurers, and the delusions which from time to time gain a hold on the public mind. 'Infant Mortality and the Environment' is the subject of an article which J. M. French, M.D., will contribute to the same magazine. Dr. French points out the chief causes of infant mortality, which are due partly to heredity and partly to the surroundings. Finally 'Beliefs About the Soul' is the title of an article by R. A. Oakes. It is full of traditions of civilized and savage peoples, relating to immortality and to plurality of souls. —— Ticknor & Co. will publish this month 'Better Times,' a volume of stories by the author of 'The Story of Margaret Kent,' 'The Philistines,' by Arlo Bates; 'Pen and Powder,' by Frank B. Wilkie, of the *Chicago Times*, a series of monographs on the late war in the West; 'Vagrom Verse,' by Charles Henry Webb (John Paul), a collection of poems, pathetic and humorous, in illuminated vellum covers: 'The Other Side of the War — with the Army of the Potomac,' letters from Headquarters of the United States Sanitary Commission during the Virginia campaign of 1862, by Katharine Prescott Wormeley, issued under the auspices of the Massachusetts Commandery of the Military Order of the Loyal Legion. Miss Wormeley, now so well known as the translator of Balzac, was a prominent worker in the Sanitary Commission, especially in the Peninsular campaign. They will also publish 'Wanderers,' being a collection of the poems of William Winter, author of 'Shakespeare's England,' etc., and dramatic critic of the *New York Tribune*. —— Elizabeth Robins Pennell, wife of Joseph Pennell of Philadelphia, and his companion through Europe on a tricycle, will have a paper on 'Wells and its Cathedrals,' in the December number of the *Magazine of Art*. In this same issue will be the first of two papers on the 'Portraits of Dante Gabriel Rossetti,' by Wm. M. Rossetti. The portraits of the poet-painter in this number cover the period from his sixth to his twenty-fifth year, and are by himself, Holman Hunt, John Hancock, J. E. Millais, and others. —— Ginn & Company announce 'Analytic Geometry,' by A. S. Hardy, Professor of Mathematics in Dartmouth College, and author of 'Elements of Quaternions;' to be published in January, 1889. This work is designed for the student, not for the teacher. Particular attention has been given to those fundamental conceptions and processes which, in the author's experience, have been found to be sources of difficulty to the student in acquiring a grasp of the subject as a method of research. The limits of the work are fixed by the time usually devoted to analytic geometry in our college courses by those who are not to make a special study in mathematics. The same firm also announce 'The Beginner's Book in German,' by Sophie Doriot, author of 'The Beginner's Book in French,' to be published Jan. 1, 1889. This follows the natural method. The lessons are introduced with a humorous picture followed by some corresponding verses from the child-literature of Germany. A conversation upon the subject, with the study of words and phrases, completes the lesson. The second part contains graded selections for reading. They have in preparation 'A Reader in Botany,' for school use, selected and adapted from well-known authors by Jane H. Newell. —— In the *Edinburgh Review* for October is a graphic description of a tornado and its effects. —— D. Appleton & Co. will publish this week in their International Educational Series, 'Memory — What it Is and how to Improve it,' by David Kay; 'Astronomy with an Opera-Glass,' a popular introduction to the study of the starry heavens with the simplest of optical instruments, with maps and directions to facilitate the recognition of the constellations and the principal stars visible to the naked eye, by G. P. Serviss; also, new editions of Drs. Lindley and Widney's 'California of the South,' and of Edna Lyall's 'Donovan.'—— Roberts Brothers will publish on the 15th 'The Man without a Country,' by Edward Everett Hale, with forty illustrations by F. T. Merrill; 'The Pil-

grim Scrip, or, Wit and Wisdom of George Meredith,' with selections from his poetry, a critical and biographical introduction, and a portrait; 'Counter Currents,' a new story by the author of 'Justina;' and a cheap edition of Shakespeare's complete works, from the text of Rev. Alexander Dyce, in seven volumes with memoir, glossary, and portrait. They have in preparation 'Jane Austen,' in the Famous Women series: 'Ethical Religion,' by William Macintyre Salter; and 'Sunday-School Stories on the Golden Texts of the International Lessons for 1889,' by Rev. E. E. Hale. —— *Wide Awake* for 1889 promises to make an unusually bright and interesting volume. Serials by H. H. Boyesen, J. T. Trowbridge, Susan Coolidge, Sidney Luska, and other notable writers are promised, as well as short stories and timely articles by John Strange Winter, author of 'Bootle's Baby,' Andrew Lang, Jessie Benton Fremont, John Burroughs, Gen. O. O. Howard, E. S. Brooks, and others. Mrs. Deland's 'John Ward, Preacher,' is in the twelfth thousand. —— Mrs. Burnett's 'Little Lord Fauntleroy' has reached its sixtieth thousand. —— A. D. F. Randolph & Co. will publish on the 25th inst. 'The Thumb Bible,' by Bishop Jeremy Taylor. —— Rand, McNally & Co. will publish at once 'The Blackhall Ghosts,' a story by Sarah Tytler (Henrietta Keddie). —— The American News Company will publish this month a story entitled 'The Curse of Marriage,' by Walter Hubbell. —— Charles W. Sever, of Cambridge, Mass., will publish on Dec. 1, 'Hesper,' an American drama, by William R. Thayer, author of 'Confessions of Hermes.' —— The Forest and Stream Publishing Co., New York, have just issued 'Bird Portraits for the Young,' the text by Dr. W. Van Fleet and the photogravure plates by H. H. Darnell. —— Dr. M. L. Holbrook, 25 Bond St., New York, will publish on the 20th inst. a work entitled 'Eating for Strength, or, Food and Work and their Relation to Health and Strength.' The author is Dr. Holbrook himself, who in this book gives 500 recipes for wholesome foods and drink. —— Macmillian & Co. will publish shortly the second series of Matthew Arnold's 'Essays in Criticism,' selected by himself just before his death. The subjects are 'The Study of Poetry,' 'Milton,' 'Gray,' 'Keats,' 'Wordsworth,' 'Byron,' 'Shelley,' 'Tolstoï,' and 'Amiel.' Lord Coleridge contributes a prefatory note to the volume. —— Dodd, Mead & Co. announce 'Musical Instruments and Their Homes,' with nearly 300 illustrations, to be published in very handsome form. The work will comprise a complete account of the collection of musical instruments now in the possession of Mrs. John Crosby Brown of New York City. Mrs. Brown and William Adams Brown have written the letter-press. The work will be of interest to students of music as well as to ethnologists. —— Charles Scribner's Sons have in preparation a second, and probably final, collection of the poems of Mr. R. H. Stoddard. It will be entitled 'A Book of Verse: Early and Late,' and will contain a reproduction of the latest portrait of this versatile writer by Mr. George B. Butler. —— W. R. Jenkins has just ready, 'Le Second Livre des Enfants,' by Paul Bercy; 'Lameness of Horses and Diseases of their Locomotary Apparatus,' by Dr. A. Liautard; and an American edition of Strangeway's 'Veterinary Anatomy,' revised by I. Vaughan. He will publish late this month or early in December 'A Veterinary Diary for 1889,' with diary leaves for memoranda and a compendium of doses; also, a work on the 'Roaring of Horses,' by Dr. George Fleming, who has given special attention and study to this particular disease. —— Cassell & Co. will publish at once George Manville Fenn's new work, 'Commodore Junk,' an adventure story dealing with buccaneering life on the West Indian Main in the days of George I. They will also publish at once Walter Crane's new colored picture-book under the title of 'Flora's Feast: a Masque of Flowers.' —— A prospectus has been issued for a 'History of Book Printing in Vienna, from 1482 to 1882.' It is intended as a souvenir of the great celebration held in the Austrian capital in 1882, on the occasion of the four hundredth anniversary of the introduction of printing into Vienna. The compilation will be by Dr. Anton Mayer; the printing by Friedrich Jasper; Wilhelm Frick will be the publisher. The work is to be in two volumes of royal quarto, with illuminated initials, and illustrations in the highest style of modern art. —— Macmillan & Co. will publish before the close of this year 'The Recluse' (hitherto unpublished) of Wordsworth. The poem will also be included in a one-volume edition of Wordsworth's poems, which will contain all the copyright notes and prefaces. This edition, which will be uniform with the popular edition of Lord Tennyson's poems, will thus be the only complete edition in the market. At about the same time Messrs. Macmillan will issue under the title, 'Wordsworthiana,' a volume of papers selected by Professor Knight from those read before the Wordsworth Society. Among the contributors are Matthew Arnold, Lord Coleridge, Lord Houghton, Mr. Hutton, Mr. Aubrey de Vere, Mr. Lowell, Canon Ainger, Mr. Shorthouse, and the editor. —— *The American Journal of Archæology*, Vol. iv., No. 3, contains 'The Relation of the Journal to American Archæology,' by the editors; 'Antiquities of Southern Phrygia and the Border Lands,' by W. M. Ramsay; 'The Ancient Coinage of China,' by W. S. Ament, missionary to China; 'Gargara, Lamponia, and Pionia, Towns of the Troad,' by Joseph Thacher Clarke; 'The publications of the German Archæological Institute,' by Charles Eliot Norton; 'The American School of Classical Studies at Athens,' by the editors; 'Publication of Inedited Documents.'

— An elaborate historical work — somewhat similar in scale to that of Mr. H. H. Bancroft for the Pacific States of North America — says the London *Academy*, is announced from Australia. Mr. G. B. Barton, of Sydney, has undertaken to write a history of New South Wales from official records, in fifteen volumes, each volume covering the term of a governor's administration. The first volume will include the letters written by Governor Phillip previous to his departure from England and while on his voyage, and also his despatches from Sydney which have not before been published. In the appendix will be given, besides the Act of Parliament founding the colony, the Governor's commission and instructions, and the letters-patent constituting the courts of civil and criminal jurisdiction, and many other unpublished records of literary and historical interest. There will also be a bibliography of the colony down to 1808. —— Mr. Richard Herne Shepherd has in hand a revised edition of his 'Tennysoniana,' first published about ten years ago. The new edition has been corrected and enlarged to date, and will contain a copious and exhaustive bibliography. —— Mr. Frederic G. Kitton has now ready for immediate publication the first part of the work entitled 'Charles Dickens with Pen and Pencil,' upon which he has been engaged for more than two years. The principal features of this work are, according to the *Academy*: (1) a description of all the portraits of Dickens, with unpublished memoranda concerning them; (2) records of his personal characteristics, with a collection of reminiscences contributed by surviving friends; (3) one hundred illustrations, including nearly fifty portraits, reproduced by line-engraving, mezzotint, etching, photogravure, etc. Queen Victoria has allowed Mr. Kitton to engrave for his collection a pencil sketch of the novelist now in her possession. The drawing, which was taken from the life by R. J. Lane, represents Charles Dickens during the Pickwickian days. Her Majesty bought it from Mrs. George Cattermole, widow of the artist who assisted in illustrating 'Master Humphrey's Clock.' It will thus be published for the first time, and will be of interest to all Dickens collectors. The mode of publication will be twelve parts, printed on fine paper, imperial quarto, each of which will contain three full-page plates. The edition is a limited one; and subscribers should address Mr. F. T. Sabin, Garrick Street, W. C., London.

— The much-delayed number of the *American Journal of Psychology* has at length appeared, dated August, 1888. Its contents differ from what the preceding numbers lead to anticipate; and it cannot be said that the change is for the better. While the main articles have been in the line of the new departures in psychology, the single contribution to this number is a minute historical study of Heraclitus. The study itself, apart from its appearance in this journal, shows unusual care and sound scholarship, and reflects great credit upon Dr. G. W. Patrick, its author. The reviews and notes continue to be abundant and interesting. They are classified under the heads of, 'The Nervous System,' 'Experimental,' 'Hypnotism,' 'Abnormal,' Anthropological,' 'Miscellaneous.' The price of the journal is advanced from three to five dollars per annum.

— The November number (No. 38) of the Riverside Literature Series (published monthly, at 15 cents a number, by Houghton, Mifflin & Co., Boston) contains four of Longfellow's most popular poems: 'The Building of the Ship,' 'The Masque of Pandora,' 'The

Hanging of the Crane,' and 'Morituri Salutamus.' Portions of the 'Building of the Ship' have been quite extensively used in schools, but the whole poem has never appeared before in so cheap a form. To those who have read (and who have not?) the 'Paradise for Children' in Hawthorne's 'Wonder Book' (see number 17 of the same series), which tells the story of Pandora's Box, the 'Masque of Pandora' will be especially interesting. The 'Morituri Salutamus' was written for the celebration of the fiftieth anniversary of Longfellow's graduation from Bowdoin College, and is considered one of his best poems. 'The Hanging of the Crane' is too well known to need more than a passing mention. These poems, while simple enough for children of the Fourth Reader grade, will be enjoyed by all lovers of Longfellow, and by all admirers of good poetry. These poems are accompanied by very carefully prepared notes, which, without being voluminous, will be found helpful at just the places where help is needed.

— In *Science*, No. 299, page 198, first column, 14th line from the top of the page, for 'house-leek,' read 'hawk-weed.'

LETTERS TO THE EDITOR.

On Alleged Mongoloid Traits in the American Race: In Reply to Dr. Ten Kate.

IN the last number of *Science*, Dr. Ten Kate makes a series of strictures on the paper I read before the American Association for the Advancement of Science, entitled 'On the Alleged Mongoloid Affinities of the American Race.' These strictures close with some sentences which I should think a scientific mind would hesitate to write, as certainly a scientific mind will refuse to accept, — sentences to the effect that any one who differs from the opinions expressed by the writer of those strictures cannot believe in either anthropology or natural history. In spite of this *egomet dixi*, I venture to retain my opinion, and even to defend it.

But first let me state clearly what were the aim and limit of my paper.

These were simply that *in our present state of knowledge* there is no sufficient ground, either in language, in culture, or in ethnic anatomy, for the oft-repeated assertion that the American Indians belong to the Mongolian sub-species of the species *Homo*. What future researches may prove, such as those of Dr. Ten Kate, I do not pretend to say; and I distinctly avoided his example of basing present theories on imagined prospective discoveries (see his remarks in his footnote).

Some of his arguments are so extraordinary that they merit special attention. Notably so is that with reference to language. He makes the astounding assertion that we should group together languages because the nations speaking them present similar physical characteristics! I need but ask if there ever lived a scientific linguist to whom this novel system occurred. Dr. Ten Kate acknowledges, that, as yet, no linguistic connection has been shown between American languages and those of the Asiatic Mongols. This is all I asserted.

Nor does my critic attempt to show a single element of Mongolian culture in America. I maintain that this culture is autochthonous; it can all be accounted for by the sociologic history of the nations possessing it; and when such is the case, it is totally unscientific to go elsewhere to seek its origin.

Dr. Ten Kate is most diffuse on somatologic points; and on these he is singularly inconsistent. He argues that the color and character of hair and skin are of little or no importance as race distinction, adducing the Teutons and Italians as examples. I differ with him here, and I deny the correctness of his observations about the color of the American Indians; but grant his position, and does it not also prove the futility of those arguments based upon the alleged identities in these respects of Americans and Mongolians? In either case my thesis would stand intact.

With regard to the relative prevalence of the *ossa Incæ*, I must retain my opinion until Dr. Ten Kate is more explicit in his figures, and the same with reference to the glabella. I am prepared to furnish statistics when called upon.

In his paragraph about brachycephaly the critic contradicts not one of my statements, although he asserts that he does. If I have anywhere said that there are no brachycephalic tribes in America, I should like the passage pointed out. His references to half a dozen authors in this connection are meaningless. Why he finds himself under the necessity of pointing out the distinction between the nasal index as determined on the bony skull and the living face, I know not. American anthropologists do not require instruction in this elementary fact. If he had been familiar with Topinard's 'Elements d'Anthropologie,' to which he refers, and which I quoted in that connection, he would have known that any intimation that I had neglected that distinction was groundless.

I shall not pursue this reply further. The reader may decide whether Dr. Ten Kate has shown a single well-established affinity between the Americans and the Asiatic Mongols. I assert he has not; and I add that such affinities are not more numerous than between the Americans and, say, the Berber tribes of North Africa.

D. G. BRINTON, M.D.

Media, Penn., Nov.

The Theory of the Origin of Species by Natural Selection.

A REMARKABLY clear conception of the elements of the theory for which Charles Darwin has become famous was published almost thirty years prior to the appearance of 'The Origin of Species.'

I have just brought home with me from London a number of geological works published in the early part of this century, among them a copy of Robert Bakewell's 'Introduction to Geology.' The passage I am about to quote from it appeared first in the fourth edition, which was published in 1833; and it is repeated in the fifth edition, published in 1838, with an interesting footnote (see pp. 403, 404).

The author is discussing Deshayes's classification of the various tertiary formations by means of comparison of the faunas with the living species. In the course of the discussion, he refers to the experiments of Robert Bakewell of Dishley, in Leicestershire, in producing choice breeds of sheep by artificial selection. He describes Mr. Bakewell's method as follows: —

"He first travelled over England, and part of the continent, to discover and select animals of the same species, possessing certain peculiarities of form, and other qualities which he was desirous to render permanent. By selecting two animals to breed from, which possessed the desired qualities in an eminent degree, and afterwards selecting from their offspring those in which these qualities were most conspicuous and breeding again from them, the peculiarities were further increased. By continuing the same selection through four or five generations, he obtained races that would transmit the same qualities permanently to succeeding generations."

Then the author applies this principle to explain the appearance of new forms of *Mollusca* in the tertiary beds, as follows: —

"Let us, however, imagine, what is very possible, that a number of individuals of one species of bivalve or univalve shell were driven, during a violent storm, into a distant part of the ocean, where the animals could no longer obtain their accustomed food, but were still able to support life by aliment of a somewhat different kind. Let us suppose that the annoyances to which they had before been subject, from natural enemies or other causes, were changed for annoyances of another kind. Under these different circumstances, is it not probable that the animals themselves would undergo some change, and modify the construction of their shells in some degree, to render them better suited to the new conditions in which they were placed? Thus, in the course of a few generations, we should have a race which conchologists would call a distinct species."

To this the author adds this footnote in the fifth edition (1838): "What was above stated hypothetically in the fourth edition of this work may now be asserted as ascertained facts. Dr. Harlan, a distinguished American naturalist, informed the author that testaceous *Mollusca* removed from one river to another in America were observed in time to change the form of their shells. Mr. Gray, in the Philadelphia Transactions, 1833, states that great varieties of form are produced in shells of the same species, by a removal from calm to agitated water."

Here the chief points of Darwin's theory of the origin of species are expressed. They are founded, also, upon observed facts. The

results produced by artificial selection are taken as examples of what would take place in nature under the assumed circumstances; and this "natural selection" is proposed as a sufficient explanation of the appearance of "a race which conchologists would call a distinct species."

The author states also, referring to Mr. Bakewell, "I have heard him say, that he scarcely knew any assignable limits beyond which these changes, both external and internal, might not be carried" (p. 402). Another statement is interesting as showing that Charles Darwin doubtless knew of this Mr. Bakewell, and may have heard him discuss these matters in his boyhood. In a footnote (p. 403) we read, "Mr. Bakewell of Dishley was in a considerable degree self-educated; but he possessed a strong original mind, which was enlightened by study and meditation. He was also a man of great moral worth, and was intimately acquainted with Dr. Priestley, Dr. Darwin, and other eminent philosophers who inhabited the central part of England, towards the close of the last century. The late Countess of Oxford once asked the author of the present work, *whether he was related to the Mr. Bakewell who invented sheep.* He replied that he was of the same Leicestershire, or originally Derbyshire family,"

It appears from these quotations that "the Mr. Bakewell who invented sheep," and the Mr. Bakewell, author of 'Introduction to Geology,' were true Darwinists before Charles Darwin. And who can tell how much of Mr. Bakewell's theory of natural selection was transmitted to the youthful Darwin through the delicious mutton of the Leicestershire Downs? H. S. WILLIAMS.

Cornell University, Nov. 3.

'Bi-daily.'

THE *Monthly Weather Review* of the Signal Service for August contains the term 'bi-daily,' as applied to the present system of indications, which are now made twice each day. That this is an incorrect use of the prefix 'bi' may be discovered by consulting a dictionary, or by reflecting upon its derivation.

The prefix 'bi' doubles the word to which it is prefixed. A biennial election is a two-yearly election, i.e., once in two years; and a bi-daily observation is an observation made every two days.

An event occurring twice each day is half-daily or semi-daily, the same as a semi-annual dividend or a half-yearly payment.

The word 'tri-daily,' which is applied to the signal-service observations, has attained by usage the meaning 'three times a day,' because of the lack of any other simple prefix. But the extension of this improper usage to the prefix 'bi' can have no warrant, since we have the correct prefix 'half' or 'semi,' both of which are already in common use. GEO. E. CURTIS.

Topeka, Kan., Nov. 1.

Buffalo on the Texas Plains.

THE re-opened discussion of the buffalo question calls for a few statements concerning these animals in Texas. Two hundred head or more of these animals may be found in the Panhandle of Texas, on the Llano Estacado, and in No-Man's Land. Some are on the Palo Duro Cañon ranch, owned by Capt. Charles Goodnight; others in the Texas Capital Syndicate, or XIT pasture, especially on the North Plains, i.e., north of the Canadian River; still others are at large. Probably twenty or more buffalo calves were captured this spring in that region and driven to Kansas for mercenary and breeding purposes. The cow-boy's ideal, like that of the more 'refined' sportsmen, is to shoot these cattle at sight, but the proprietors of the ranches are doing much for their protection.

There are also many buffalo on the South Plain. The antelope, black-tailed deer, and many rare but smaller mammals, are found in the same region — all of which I saw or heard of during a recent visit to Plaza Larga, Tucumcarri Mesa, and the Texas Panhandle. Naturalists desiring these forms should go to Tascosa, Tex., near the New Mexican line, a place easily accessible from Kansas, Denver, and Texas, *via* the Fort Worth and Denver Railway. The capture of wild horses is a profitable pursuit in this region.

ROBT. T. HILL.

University of Texas, Austin, Nov. 7.

Answers.

37. WHAT NUMBERS DOES IT TAKE TO MAKE A BILLION? —Responding to Query 37 (*Science* xii. 204), 'What numbers make a billion?' I would offer the following remarks: The term 'billion' appears to have been introduced by the Italian arithmeticians early in the fourteenth century. Peacock, in his admirable history of arithmetic (*Encyclopæd. Metropol.*, vol i.), states that the Italians made "a great addition to their former numerical language by the use of the word 'millione' (which properly signifies 'great thousand') to denote the square of one thousand; and which was followed by the words 'billione,' 'trillione,' etc., deduced immediately from the form by pursuing the natural analogies of the language: a series of numerical terms was thus formed, proceeding not by tens, but by millions." The new terms were slowly adopted by the nations of Europe, but in every case in their original and etymological sense.

In Spain these terms were used probably not long after their establishment in Italy; in France they were adopted not much before the opening of the sixteenth century; in Germany, early in the sixteenth century; in England, not till the close of the seventeenth century; and in Russia, early in the eighteenth century. Locke, who published his great essay in 1690, complains that his countrymen were accustomed to speak of millions of millions of millions instead of using the more convenient term 'trillions;' and he gives an example of the proper notation to sixty places of figures, divided into sextuple periods, and duly named up to nonillions. "The ordinary way of naming this number in English will be the often repeating of millions of millions of millions of millions," etc. (*Human Understanding*, book ii. chap. 16, sect. 6). It is important to observe, that, wherever introduced, the term 'billion' uniformly designated the *bis* power of the million, — a value, the prefix to twelve places of figures. In the Italian dictionary of the Accademici della Crusca, the word 'bilione' (or 'billione') is defined, "un milione di milioni." In the Spanish dictionary of the Academia Española, the word 'billon' is defined, "un millon de millones," or a million multiplied by itself. In the German dictionary of Dr. Daniel Sanders, 'billion' is defined, "millional million." And in Littré's 'French Dictionary,' after defining the word, it is stated, "The forms billion, trillion, etc., were devised in the sixteenth century to signify periods of six to six figures: counting from the right, units were represented by the first six places of figures, the millions were represented by the figures from 7th to the 12th places, the billions were represented by the figures from the 13th to the 18th places, and so on." Est. De La Roche's 'Arithmetique' is quoted as stating, "A billion is equal to a million million." Littré adds (without explanation), "It was not till the middle of the seventeenth century that the rule of separating into periods of six, was changed to separating into periods of three figures, and the original *billion* was divided by 1,000." It is not a little surprising that our compilers of school arithmetics (whether smitten with Francomania or with Anglo-phobia) have almost unanimously adopted the modern French perversion of the terms 'billion,' 'trillion,' etc. And thus business-men are in the habit of numerating '-illions' by places of three (*after the million place*), while astronomers and mathematicians preserve the original and logical numeration by places of six figures. It needs but a bare inspection of the terms themselves to see that this French neologism (of the last two centuries) is not only anomalous, but wholly irrational. The form of the words 'million,' 'billion,' 'trillion,' 'quadrillion,' 'quintillion,' etc., necessarily denotes some co-ordination of numerical progression. What can it possibly be on the pedagogue's system? The expression 1 000,000 000 (one thousand million) does not admit any logarithmic bisection. How can it, then, be in any sense a *billion?* If it be any kind of a *bis*, what is its primary? It is an impossible second power, having a surd for its root. Had the French arithmeticians cut down at the same blow the *million* to the *mille*, the scheme would at least have been consistent. A true billion is evidently a *second* order of million, and the only rational order is the second power.

To any reflecting mind the school-book numeration is simply absurd, and its prevalence is a very puzzling phenomenon.

W. B. T.

Washington, D.C., Oct. 30.